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Published in:
EcoDesign '99: First International Symposium On Environmentally Conscious Design and Inverse Manufacturing, 1999. Proceedings.

Link to article, DOI:
10.1109/ECODIM.1999.747640

Publication date:
1999

Document Version
Publisher's PDF, also known as Version of record

Danish Experience with the EDIP Tool for Environmental Design of Industrial Products

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Abstract

Since its publication it7 1996. the Danish method and tools for Environmental Design of Industrial Products (EDIP) have beet7 used it7 companies it7 Denmark and abroad. and experience has beet7 gained with a variety of product categories such as: electronics. electromechanical products, furniture. foodstuffs. packaging. textiles. building equipment, energy systems. and railway systems. The experience shows, that large environmental improvement potentials can be found in all product categories. As a broad average. 30-50% environmental improvement of products have been implemented over few years by companies working with the EDIP tools. The paper presents examples from pumps, refrigerators. high pressure cleaners. audio/video producrs. book shelves and moulded cardboard.

A *questionnaire investigation of the experience with LCA and eco-design within the Danish pioneer companies in the area was made in November 1997. A total of 39 companies, known to have worked more or less with LCA and eco-design. were contacted. and 26 companies volunteered to participate. The investigation covered from small (8 employees) to large (>7000 employees) companies having from very little to several years of experience with LCA and eco-design. The attitude towards the disciplines were mainly positive:* 70% *of the companies claim. that the LCA work has resulted in new priorities it7 product development. More than* 70% of *the companies stated, that they would continue include LCA it7 their product development it7 the future. About 80% of these companies use the EDIP method and tools.*

1. Background

The Danish method for Environmental Design of Industrial Products (EDIP) was developed over a 5 year period from 199 1 to 1996 by a team comprising: five major Danish companies within the electro-mechanical industry. the Confederation of Danish Industries, the Institute for Product Development (project leader). and the Danish Environmental Protection Agency (sponsor). This three-sided collaboration between industry. university and authorities throuphout the project has provided a balance between requirements for operationality and scientific depth of the methods. The project comprised about 50 man-years of work in all.

The direct results of the project were:

- a method for Life Cycle Assessment of products - a tool for the environmental specialist
  - in book form, cf. WENZEL et al. (1997) and Hauschild and Wenzel (1998)
- a method and framework for environmental design of products a tool for the product developer - in book form. cf. Olesen et al. (1996)
- a database with environmental information on about 400 essential materials and processes covering the life cycle of electro-mechanical products as well as other product categories - on diskettes including a manual. cf. Frees and Pedersen (1 996)
- a PC-tool (presently in beta-version). building on the database. to sustain environmental assessment and design as specified by the methods as PC software including a manual. cf. Pedersen et al. (1998)
- integration of the methods and tools in the product development routines at the participating industrial companies
- substantial environmental improvements of a wide range of products at the participating 5 companies. sold in large volumes world wide
- a collection of case histories documenting the procedure and experience in use of the method and tools at the 5 companies and the achieved environmental improvements - in book form. cf Wenzel et al. (1997)
- an exercise book supplementing the method textbook for teaching at university courses (in book form and disk for cut & paste. cf. Wesnaes (1997)
- a dissemination campaign (1996-97) aiminp at Integration of the methods and tools in both industry

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and universities **in Denmark, Europe and world wide.**

	Environment	Resources	Working environment
Global	**Global warming** **Stratospheric ozone depletion**		
Regional	Photochemical **ozone formation** Acidification Nutrient enrichment Persistent toxicity - Human toxicity from the water compartment - Human toxicity from the soild compartment - Chronic ecotoxicity in the water compartment - Chronic ecotoxicity in the soil compartment	Fossil fuel, e.g. oil, coal, brown coal and natural gas Metals, e.g. Fe, Al. Cu, Zn. Ni, Cr, Mn. Ag and Au Other minerals, e.g. lime, phosphate and salt Others	
Local	Ecotoxicity - Acute ecotoxicity in the water compartment Human toxicity - Human toxicity from the air compartment Land filling - bulk waste (non-hazarous) - hazardous waste -slag and ashes -nuclear waste	Biomass, e.g. wood, straw and grain Water, e.g. groundwater, surface water and water for hydro electric power Others	Cancer due to chemical substances Damage to the reproductive system due to chemical substances Allergy due to chemical substances Damage to the nervous system due to chemical substances Musculoskeletal injuries due to monotonous repetive work Hearing Impairments due to noise Grievous bodily harm due to accidents

Table 1. The EDIP method's assessment criteria

The EDIP books were translated into English in **1997. and the PC-tool is planned to be translated into** English **soon.**

2. Key characteristics of the method

The EDIP method is in compliance with the methodological requirements of the IS0 14040 standard and the drafted requirements of the forthcoming standards 14041, 14042 and 14043. It does not contain requirements for reporting and external reviews. though. for the reason that it is designed for the internal use in product development and not for marketing/external information purposes. The data format and the transparency of the method do, however, meet the requirements of the standards, and the method can. thus. be used for external purposes as well as internal.

The method consists of 6 phases:

1) **Goal definition – identifying the specific assessment task** to be solved in product development and the potential environmental scenarios related to the decisions taken during that stage of product development
2) Scope definition – identifying the methodological requirements for the assessment task in question and the scope of the systems to be studied
3) Inventory analysis – compiling an inventory of the environmental exchanges from the studied systems
4) Impact assessment – assessing the resource consumption and environmental impacts of the environmental exchanges identified in the inventory
5) Sensitivity analysis – identifying which parameters are essential, their uncertainty and the significance of their variation
6) Decision support – providing support to the different types of decisions to be taken during product development

These phases are the same as specified by IS0 14040, where "sensitivity analysis" and "decision support" correspond to ISO's "interpretation".

The method is characterised by being designed for the use in development of complex products. It addresses all impact categories quantitatively, including resource consumption, environmental impacts, and impacts on working environment, cf. the overview given in Table 1.

2.1 Impact assessment

One of the important characteristics of the method is the impact assessment phase. As most LCA methods, the EDIP method includes a characterisation step, where inventory data are transformed into potential contributions to the various environmental impact categories comprised by the method. International consensus exists to a large extend on the characterisation of impacts on global warming, ozone depletion, acidification, nutrient enrichment and photochemical ozone formation, and the EDIP method is in line with this consensus. On the toxic impacts on humans and ecosystems, consensus is further away, and the EDIP method has developed its own procedure for assessment of toxicity.

Like for other LCA methods, it has not been possible to model the environmental exchanges for the part of the product system, that constitutes landfills. The potential impacts from landfills are instead visualised in four different categories of waste, cf. Table 1 and 2. In parallel to the work with the EDIP method, though. work has been done at our institute to overcome this problem, and a tool has been developed to model product related emissions from landfills (Nielsen and HauschilD,1997), (Nielsen et al.. 1998). Further work goes on in this field, and it is the plan to integrate this into the EDIP tool.

To illustrate the environmental impact assessment procedure of the EDIP method, an example is presented of an assessment of two different refrigerators, i.e. one with pentane as foaming agent and iso-butane as cooling agent and one with a hydro-fluoro-carbon (an HFC) called R134a for both foaming and cooling. Table 2 shows the first step of the assessment, the so-called characterisation step. where emissions are expressed in impact equivalents within each of the impact categories comprised by the method.

Environmental impact potentials from refrigerators

Impact categories	Unit	Pentane/iso-butane	R134a
Global warming	g CO_2-eq	870,000	2,270,000
Ozone depletion	g CFC 11-eq	0	0
Photochemical ozone formation	G C_2H_4-eq	101	63
Acidification	g SO_2-eq	6,820	8,000
Nutrient enrichment	g NO_2-eq	4,380	5,150
Ecotoxicity, water, chronic	m^3 water	44.000	44,000
Human toxicity, water	m^3 water	1,610	1,610
Ecotoxicity, water, acute	m^3 water	2,160	2,160
Human toxicity, air	m^3 air	563,000,000	613,000,000
Hazadous waste	g	185	185
Nuclear waste	g	0.05	0.05
Slag and ashes	g	20,300	24,300
Bulk waste	g	165,000	194,000

Table 2. Environmental impact potentials from refrigerators

As seen from the table, it is not easily judged, which one of the two refrigerators is the environmentally preferable, because there is a trade-off primarily between high photochemical ozone formation in the alkane based refrigerator and high global warming potential in the HFC based refrigerator. This example is taken from Mose et al. (1997)

To get a feeling of the order of magnitude of the contributions to the different impact categories – what is much and what is little – a normalisation is performed. The EDIP method uses the background contribution from the whole society as normalisation reference. For the global impact categories, i.e. global warming and ozone depletion. the global background load is used. For the regional and local impact categories, the Danish background load is used. In both cases the year 1990 is used as reference. In order to normalise to a common scale, the background loads are expressed per inhabitant of the area in question, i.e. the World and Denmark respectively, and the reference load used for normalising the load from the studied product system is thus the load from an average person. After normalisation, the product's contribution to the different impact categories is hereby brought on the same scale, namely the ratio of the product's contribution compared to the average person's contribution in 1990 or the *person equivalent* 1990. Figure 1 shows the normalised contributions to selected impact categories from the two refrigerators from Table 2. The figure shows, that compared to the background load, the reduction in global warming potential from the alkane based refrigerator is much larger than the increase in photochemical ozone formation potential.

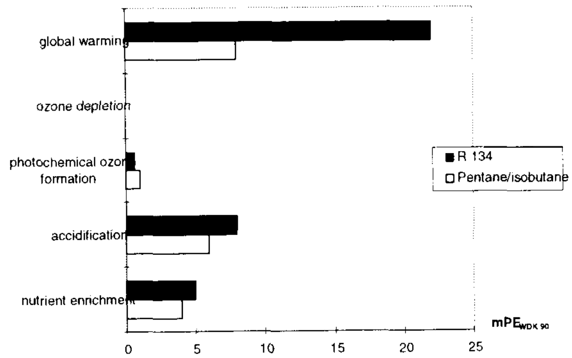

Figure 1. Normalised contributions to selected impact categories from the two refrigerators

The final weighting of impacts against each other is done on a distance-to-target basis in the EDIP method. The full set of environmental targets in Danish legislation, environmental action plans and international conventions to which Denmark has subscribed, is used to identify the targets for reduction of the Danish contribution to the different impact categories. These reduction targets are normalised to the year 2000 and they thus express the target for reducing society's contribution to the different impact categories from 1990 to 2000. The unit after weighting, thus. becomes the *targeted pet-son equivalent.* i.e. the '*acceptable" environmental impact from a person in year 2000 according to the sum of political targets.

Figure 2 shows the weighted contributions to selected impact categories from the two refrigerators. The Danish reduction targets for greenhouse gases and emissions contributing to photochemical ozone formation are quite similar, namely 30% and 20% respectively. The weighted picture is. therefore, quite similar to the normalised picture. Also after weighting according to the sum of Danish environmental policies. the alkane based refrigerator seems to be preferable. On top of these normalised and weiphted pictures come other considerations like the points that created ozone has a short life. few days to a week. as opposed to greenhouse gases, that persist for hundreds of years in the atmosphere plus the point that the potential impacts from global warming are global and potentially more serious than potential impacts from ozone and other created oxidants that are regional. These points tend to support the conclusion that the alkane based refrigerator is environmentally preferable.

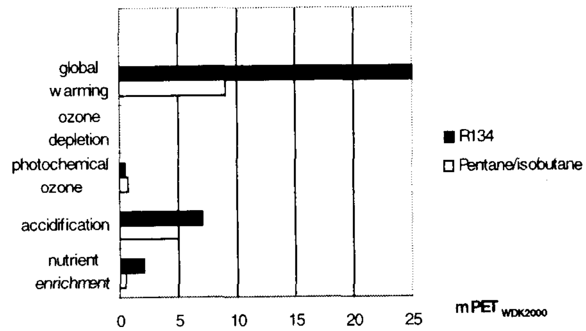

Figure 2. Weighted contributions to selected impact categories from the two refrigerators

Normalisation and weighting are in the EDIP method closely linked. and like for any LCA method. they are to a wide extent normative. Important elements of the reasoning behind the normalisation and weighting procedures in the EDIP method arc:

Firstly. the unit after normalisation is pedagogic and understandable. Normalising with the average person's background load and expressing the product's contribution in person equivalents allows the decision maker to see the product in percentage of hers/his own average activities in life. The unit, thus, has an understandable meaning of its own which facilitates interpretation.

Secondly. normalisinp with a background load that is *known* by the decision maker facilitates weighting and interpretation. After having normalised. the weighting between impact categories becomes a weighting between the known background loads in 1990: how serious were these actual loads compared to each other? Not a general weighting of e.g. acidification as such against global warming as such. The reference background load being known and its environmental impacts being experienced. facilitates weighting of the impacts against each other.

Thirdly. having normalised with the global and national background loads respectively. allows for the use of the work done internationally and nationally in assessing the impacts and the needs for reducing them. For the global impacts. international reduction targets exist. and for the regional local impacts. national reduction targets exist. These targets express how much the background load should be reduced. and to some extent they thus express. how serious they are perceived to be. compared to each other. The national targets do express the national priority, and if the company is e.g. Danish. it bears relevance to use a Danish priority in weighting.

Fourthly, the use of politically stated reduction targets integrates scientific and political regards and ensures a uniform environmental strategy in society. By this way of weighting. the preventive measures of industry in product development will follow the same priorities as the sum of other measures across sectors in society. The impact assessment part of the LCA. in this way becomes a management tool. that allows society to ensure, that product oriented environmental initiatives pull in the same direction as other environmental initiatives in society.

Fifthly, the unit after weighting is equally pedagogic and understandable. The unit has its own meaning, i.e. the percentage of the impact "acceptable" from an average person in the year 2000 according to political targets, which facilitates the interpretation of the unit.

Last but not least, the normalised and the weighted figures for the environmental impacts of the product are only a support for the interpretation. They help the decision maker to get an overview of the problem and of priorities behind the decision. The normalised and the weighted figures can be used independent of each other and each have their own value as decision support. And the decision maker can use his/her own values and priorities on top of or beside the ones behind normalisation and weighting in the method, as long as it is done in a transparent way. It is important that units after normalisation and weighting have their own meaning, for this allows the decision maker the see through, what kind of values and regards they include and what they do not include. The authors are, thus. opposed to weightings ending up in eco-points. environmental load units and other such single metrics that bear no meaning in themselves. and thus do not provide the user of them with an understanding of what they include.

2.2 Further developments in impact assessment

Further development of the EDIP method is taking place. and among other things data on background loads in other European countries are being collected. Normalisation references are being developed for countries in Europe and for a European average allowing to express the product in European person equivalents. Furthermore. reduction targets in the different European countries are being investigated allowing also for compiling an average European weighting and target person equivalent. Also other countries have been investigated. and recently the EDIP method was supplemented normalisation and weighting into Chinese person equivalents (Yang and Nielsen, 1998).

3. Experience with eco-design and the use of the EDIP tools in Danish Industry

A questionnaire investigation was made late 1997 of the experience with Life Cycle Assessment (LCA) and eco-design within Danish companies (Broberg et al. 1998). A total of 39 companies known to have worked with LCA and cco-design to a smaller or larger extent were contacted and out of these. 28 companies volunteered to take part in the investigation. Of these 28 companies. 26 turned in the answers. The companies can bc described as being the LCA pioneer companies in Denmark having different degree of LCA experience ranging from a few months of work to several man-years. Almost all companies had used consultants in part of the work. and in average 40% of the work was performed by consultants while 60% was performed by the company.

The general attitude towards LCA was positive. Over 70% of the companies stated. that the LCA-work has resulted in new priorities in product development and over 70% of the companies stated that LCA will be used in product development in the future. See figure 3. 4 and 5. The EDIP method was used by around 80% of the companies.

	ves	no	do not know
Has workinp with LCA resulted in clarifying priorities for environmental performance in future product development?	70%	18%	12%

Figure 3. Questionnaire to Danish Companies

	yes	no	do not know
Will LCA be integrated in future product development'?	70%	20%	10%

Figure 4. Questionnaire to Danish Companies

	very large	large	some	small
With which effort will LCA be integrated in future product development?	10%	28%	28%	14%

Figure 5. Questionnaire to Danish Companies

The general experience is, thus, that LCA work in the company opens for new directions in product development and that major environmental achievements are realised when starting eco-design. An average of 30-50% environmental improvements has been experienced at Danish companies working with the EDIP tools.

sometimes even more. Examples of LCA's and eco-design at manufacturers of pumps. refrigerators, high pressure cleaners, audio/video products. book shelves and moulded cardboard are presented in the following.

3.1 Grundfos A/S, pumps

Grundfos A/S is one of the largest pump manufacturers world wide. One of the company's main products is the small circulator pump used in central heating in households, and the company covers about 50% of the world market of these pumps. Grundfos has estimated, that approximately 0,1% of all electricity world wide is consumed by Grundfos products.

At Grundfos, all product development projects have to consider 3 environmental aspects. namely: 1) Potential environmental impacts, 2) Use of limited resources and 3) The working environment at the production site. Task 1) and 2). is handled by the use of the EDIP-method and tools.

Grundfos states. that by using a database of "unit processes" as described in the EDIP-method, it is possible to do an LCA-screening within a limited time period acceptable in the stage of the initial decision point in the idea phase of the product development. This LCA-screening is made by the Grundfos LCA-specialist in co-operation with the Project Manager. The results of the screening will typically result in one or two environmental focus areas for the new product. The group of designers/constructors will thus have environmental guidelines for developing the product towards the decision point in the product concept phase. When the designers/constructors have designed the product and decided on the technical solution, they do have the opportunity to bring back the LCA-expert to the project at this stage. if the technical solution is in conflict with the environmental guidelines set earlier on. However, at this point. a technically good solution will often be an environmentally sound solution in the view of the total life cycle. so there is often no trade-off situation.

In the following example there was a trade-off situation in the concept phase. The traditional circulator pump was undergoing a new development. The idea was to integrate an electronic control of the pump to reduce the energy consumption in the use stage. It was demonstrated that this improvement in the use stage would increase consumption of more energy and resources in the material- and the production stages of the product's life and make recycling of the pump more difficult because of the added electronic control unit.

The two alternatives, the traditional pump and the pump with the added electronic control unit were described in a life cycle scenario, and the EDIP-tool was used to make the environmental assessment. In order to illustrate the influence of the electronic unit in disposal, the whole unit was anticipated to be hazardous waste, which is of course a conservative approach. See figure 6.

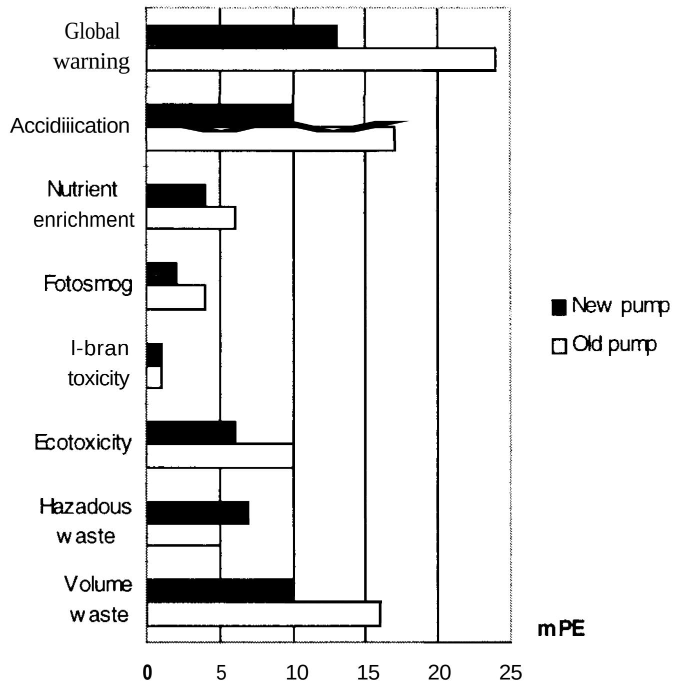

Figure 6. **The two alternative pumps**

To Grundfos, the conclusion was clear. The reduction in total life cycle energy consumption was about 40%, and the reduced environmental impact due to this was much larger relative to the increase in hazardous waste. even if the whole electronic unit was anticipated to be hazardous. Grundfos now produces these circulator pumps and have high expectations of their market share.

3.2 Gram A/S, refrigerators

Gram A/S is an, on the global scale. small or medium size company with around 2000 employees. The company manufactures high quality domestic and commercial refrigerators and freezers. The company has done very comprehensive LCA work with the EDIP tools including so-called environmental diagnoses, i.e. a number of "what-if" simulations of the environmental consequences of a number of potential options and directions to follow in product development. Figure 1 and 2 illustrates one of these simulations, namely an analysis of the environmental consequences of alternative choices of coolant and foaming agent discussed in Section 2.1. The company uses at present the HFC as coolant and refrigerant, but is beginning to introduce alkanes instead.

Another simulation was of the theoretical improvement potential be improving the energy efficiency. divided between theoretical improvements of the evaporator, the compressor. the whole cooling system and the whole cooling system plus the insulation. The simulations were done on an alkane based refrigerator in order to eliminate the contribution to global warming from coolant and foaming agent. Figure 7 shows the simulation for one selected impact category, namely global warming. to which energy consumption in the use stage (before potential product alterations) contributes more than 80%. As evident from the figure, the theoretical improvement potential from an improved energy efficiency is large, and Gram A/S finds the direction worth pursuinp. The company initiated development of an electronic control of the compressor by a frequency converter in collaboration with the manufacturer of the compressor and has now produced a pilot refrigerator saving about 40% of the energy in the use stage. The company expects this solution to be implemented in freezers first and later in refrigerators.

As evident from the examples, it is valid for refrigerators, as also for the pumps in the previous example, that a few options/focus points can be pointed out as *the* largest environmental improvement potential without comparison. In this case substitution of the HFC coolant and foaming agent and improving energy efficiency stand for over 80% improvement potential as a broad average of impact categories.

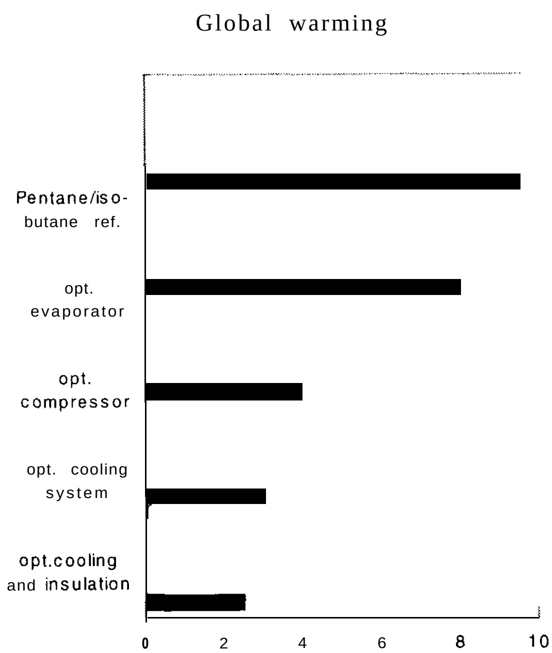

Figure 7. Simulations of energy optimisations in the an alkane based refrigerator

3.3 Alto Denmark AJS, high pressure cleaners

The company Alto Denmark A/S is the largest Danish manufacturer of high pressure cleaners and a company with about 700 employees. The company has donc comprehensive LCA work usinp the EDIP tools resulting in an overview of environmental priorities. Figure 8 shows a weighted profile of impact potentials divided between different sources of impact, namely: use of materials, disposal, use of chemicals (ancillary substances). use of electricity and use of thermal energy, being aggregated over the whole life cycle for all source types.

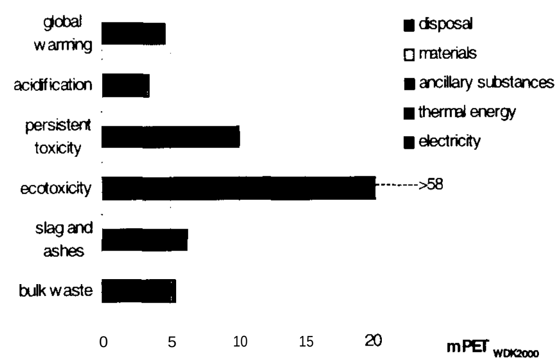

Figure 8. Weighted profile of impact potentials divided between different sources of impacts for a high pressure cleaner

The figure shows, that electricity consumption (of which 80% is in the use stage) and chemicals (being primarily the detergents in the use stage) stands for over 90% of the impact potentials. Alto Denmark has acknowledged these two priorities and have achieved large improvement in both areas. By a new design of the nozzle, a combined hydraulic and mechanical shaping of the water jet implying a large improvement of the pressure drop profile of the jet, about 30% saving of water and energy was achieved without reduction in cleaning effect. Furthermore, Alto Denmark estimates a 50% saving of detergents by a new system for dosing the detergents in the nozzle with a simultaneous mixing with air. The system implies more foaming of the detergents making them stick longer to the surface and visually influencing the user to use less detergents as detergents are often added to achieve a certain foam level.

3.4 Bang & Olufsen A/S, audio/video products

Recently, the company Bang & Olufsen. being a Danish manufacturer of high quality audio and video products, has developed a new amplifier under the name of "cool power". The amplifier uses around 10% of the energy of a conventional amplifier an the sound quality is improved. Bang & Olufsen is in the process of getting the product patented. Ban8 & Olufsen use the EDIP tools on a routine basis in product development and does screenings of new products in the idea phase. Also the amplifiers were screened and it was clear that energy consumption was top priority. The development of the "cool powcr" was, however, done as a technology development project including a Ph.D. prior to implementation of the new concept in product development.

The amplifier is the main energy consumer in audio products and the energy saving by substituting conventional amplifiers by "cool power" is around 50% in radios and other audio equipment.

3.5 Montana A/S, furniture

Montana A/S is a small company producing high-end furniture in module based systems including tables, book shelves and cupboards. The company engaged in Life Cycle Assessment of a book shelf with the purpose of identifying the most essential improvement potentials and implementing improvements in design of a new shelf. The concept generally followed was book shelves in wood lacquered with and acid curing top lacquer. and the company wanted to open the options fully an identify potential improvement by choice of new concepts including choice of new materials and new manufacturing processes including new surface treatment. Many "what-if' simulation were carried out according to the EDIP methods diagnosis tool, and the single most environmentally beneficial option was assessed to be the substitution of the acid curing top lacquer by a UV sealer. As figure 9 shows. the reduction in environmental impacts was more than 50% in the weighted picture due to the substantial reductions in human toxicity, persistent toxicity and photochemical ozone formation potentials.

Montana subsequently implemented this solution in new book shelves.

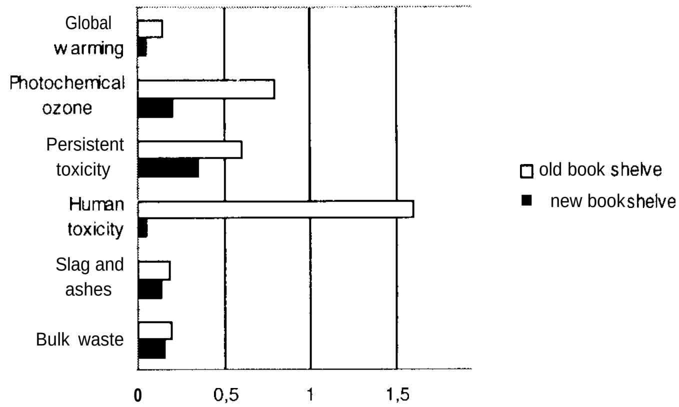

Figure 9. Simulation of UV sealer versus acid curing top lacquer as surface treatment of Montana book shelves (Lassen and Nielsen, 1998)

3.6 Hartmann A/S, moulded cardboard packaging

Hartmann A/S produces packaging in moulded cardboard from recycled paper and machines/factories for moulded cardboard production. The company owns factories in many countries and has licence agreements with other producers in more than 20 countries. The main product is egg trays, but a large variety of moulded cardboard packaging is produced. The company has used the EDIP method in LCA work for over 5 years. The LCA pointed to the fact. that the company's own manufacturing was the single most important stage of the life cycle. This was found to be due to the fact. that the recycled paper is suspended in water during the pulping. as in all paper and cardboard production, in order to enable the moulding of the new cardboard product. and that the cardboard of course subsequently has to be dried again. About 80% of the energy consumption from the manufacturing process derives from the drying.

Hartmann acknowledged this focus point and have given high priority to improvements on energy consumption. Firstly, the company invested in a co-generation heat and power plant based on natural gas. substituting the existing system with oil boilers and electricity from the grid. Secondly, the drying ovens were equipped with heat exchange and heat was sold to the municipality. Thirdly. Hartmann is now testing a new concept for reducing the water content of the pulp prior top drying in order to save energy in the ovens. In all, the measures at the manufacturing site at Hartmann has reduced the environmental impacts seen over the whole life cycle by more than a factor 2.

4. Discussion – responsibilities in eco-design

The reason to include the here presented six examples in some detail is to underline the two main points we aim to make in this paper.

The first point is. that improvement potentials are large in almost all product categories. Looking at the product over its whole life cycle is a new concept for most companies. and large improvement potentials are found when seeking optimisation in this holistic view. There is no link between environmental propertics of the product and manufacturing costs implying increased costs for environmentally friendlier products. On the contrary, it is more often seen, that environmental improvements lead to reduced costs, than vice versa. The EDIP method implies, that the environmental properties of the product are dealt with on an equal basis with other properties and considerations being built into the product, and the experience has shown. that this is fully possible. Building environmental considerations into the product does not affect business opportunities negatively, and for some product categories it is experienced to affect business opportunities positively.

The second point. we would like to state as a provocation for the purpose of the discussion: eco-design is not for designers. In the same breath, we will modify this provocation a little. Our point is, that the environmental assessment (LCA) and the "what-if' simulations of the product and of improvement options and directions most often point to a few options that stand for major improvement potentials, say more than 80% improvernent, and that decisions on these options typically lie with the company management or with someone else higher in the decision hierarchy than the designer. Typically, the environmentally most interesting options require some technology development, like e.g. electronic control of the pump at Grundfos or the compressor at Gram and the cool power at Bang & Olufsen, or they require such big alterations at the company, that the decision lies at top level like e.g. the change of coolant and foaming agent at Gram. the introduction of new lacquering process at Montana and the change of energy system and introduction of de-watering technology at Hartmann. Furthermore, the identified priorities are typically valid for the whole product "family", e.g. electronic control of circulator pumps and compressors are environmentally highest priority for all variants of the products within these families at the company, UV sealer for all indoor wooden furniture, cool power amplifier in all audio products, etc. This implies, that the environmental assessment, the LCA work, is preferably done centrally at the company, and simple guidelines and targets are specified for the designers in subsequent product development projects. The guidelines and targets for the designer has thus translated into conventional product properties such as energy efficiency_ or bound tasks to make use of specific concepts or technologies. Our experience from Danish companies is, that this is the way things turn out. and also that this is the way it actually works with success. Now, our own modification is. that many sub-optimisations can be found at the design stage, and that also many solutions to generally specified optimisation requirements like "optimise energy efficiency" can be found at the design stage, cf. e.g. the development of the new nozzle and foaming principle at Alto Denmark.

We thus identify three main stakeholders having each their type of responsibility in eco-design. Firstly, the environmental specialist being responsible for environmental assessments of the products from a life cycle perspective and for identifying environmental priorities. Secondly, the company management/-management of product development being responsible for assessing business opportunities and setting company strategies and targets for the individual projects. Thirdly, the designer being responsible for fulfilling targets and following guidelines. We have put this quite roughly, and we realise that interaction between these stakeholdcrs and intermediates between the defined responsibilities exist. Not being designers or experts in product development procedures, we submit ourselves undoubtedly to criticism. But the provocation shall be seen in the light, that at the other end of the interval of this discussion. LCA tools are still being developed for designers, tools that typically comprise translation of results into single metrics, and used on a routine basis by designers comparing environmental scores of detailed solutions in daily choices - 7 is less than 9. Our experience is, that this is not what leads to the significant environmental improvements of products.

5. Conclusion

The main conclusions are, that

- Danish companies are beginning to use Life Cycle Assessment and eco-design. and that the companies have good experience and want to continue.
- large environmental improvement potentials can be found in almost all product categories. that environmental regards fit well into product development on an equal basis with other regards.
- the EDIP tools are being adopted by industry and that they fulfil their purpose of supporting Life Cycle Assessment and eco-design successfully.
- LCA should be done centrally at the company. that the most significant environmental improvement options and directions require decisions at a level higher than the designer, and that guidelincs and targets can be developed for the designer, that are generally valid for the whole family of products in question.

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